Extracellular matrix graft for reconstruction over exposed structures: a pilot case series

Objective: Soft tissue defects, especially those involving exposed vital structures, present a reconstructive challenge because poor vascularity of such defects typically makes immediate skin grafting unviable. Where flap procedures are inappropriate or not possible, dermal matrices represent an alternative reconstructive option for defects with denuded vital structures. With dermal matrices becoming increasingly available and technologically advanced, we evaluated an ovine-derived extracellular matrix graft in the reconstruction of complex soft tissue defects involving exposed vital structures.
Method: Six cases of soft tissue defects exhibiting denuded vital structures underwent reconstruction using an ovine forestomach matrix graft as a dermal matrix. Grafts were fixed directly into defects for immediate coverage and subsequently temporised defects via granulation tissue formation for later skin graft or secondary closure. Defect granulation and epithelialisation were monitored until closure and the final aesthetic and functional outcomes were evaluated.
Results: Complete healing was achieved in all cases, with defect granulation becoming observable within one to two weeks and complete granulation occurring within one to six weeks. Granulation tissue resulting from the graft was suitable for skin grafting, with 100% take of skin grafts after one week and complete re-epithelialisation in two to three weeks in the four cases that received a skin graft. Good cosmetic, functional and patient satisfaction outcomes were achieved in all cases.
Conclusion: The present series demonstrates our initial use of an extracellular matrix-based dermal matrix in reconstructing defects with exposed vital structures. While such dermal matrices do not supersede or replace flap procedures, they represent an alternative option on the reconstructive ladder in cases where flap procedures are not appropriate or possible.
Declaration of interest: The graft (Myriad Soft Tissue Matrix) was provided by Aroa Biosurgery Limited (Auckland, New Zealand). AEC and GAB have received educational travel grants from Aroa Biosurgery Limited.

dermal matrix • diabetes • dressing • exposed bone and tendon • extracellular matrix • ovine forestomach matrix • reconstructive surgery • wound

Reconstruction of defects presenting denuded vital structures is challenging. Exposed vessels, nerves, tendons, joints and bone must be promptly covered but immediate closure via a split-thickness skin graft (STSG) is not always a viable option. If not covered with adequately perfused soft tissue, exposed vital structures are at high risk of desiccation, necrosis and/or infection, posing severe functional consequences.[1] As exposed vital structures often have insufficient vascularisation to support an STSG, more complex surgical techniques from the reconstructive ladder are required.[2] Flap reconstruction is typically employed for coverage of exposed structures and to provide definitive closure. Depending on the nature of the defect and surrounding tissues, flap reconstruction options can range from relatively straightforward fasciocutaneous flaps to free flaps requiring more complex microvascular surgery. Flap techniques are recognised as reliable options for reconstruction of complex defects but, depending on the specific defect, flap type and patient factors, flap reconstruction may be complicated by dehiscence, infection, thrombosis, seroma/haematoma, ischaemia and necrosis.[3] Such complications require medical intervention to stabilise compromised flaps and additional surgery may be necessary to attempt salvage because flap failure has severe impacts on the reconstructive outcomes.

Dermal matrices (also called 'dermal substitutes' or 'dermal templates') are biomaterials typically comprised of collagen and/or other extracellular matrix (ECM) components. These devices are designed to act as biomimetic substitutes for soft tissue ECM and scaffold soft tissue regeneration prior to STSG placement or closure via secondary intention.[4,5] A range of dermal matrices are now commercially available, from products synthetically formulated using reconstituted collagen and other ECM components (e.g., Integra (Integra LifeSciences Corporation) and Matriderm (MedSkin Solutions Dr. Suwelack AG)) to decellularised ECM xenografts (e.g., Surgimend (Integra LifeSciences Corporation)) and allografts (e.g., Alloderm (Allergan plc)) that consist of purified tissue ECM.

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Ovine forestomach matrix (OFM) is a decellularised xenograft ECM biomaterial composed of over 150 matrisome proteins,[6] and an open porous architecture to support cell infiltration.[7–10] OFM is manufactured from ovine forestomach using processes to remove the ovine cells, while retaining the architecture and composition of the tissue ECM. Clinically, OFM-based devices have been used in hard-to-heal wound management, plastics and general surgery.[11–14] More recently, OFM has been fabricated into multilayered grafts, called 'Myriad Soft Tissue Matrix', designed specifically for use as a dermal matrix in deep partial or full thickness defect reconstruction, as well as implant procedures. In the present case series, we describe our initial experiences using the OFM graft as a dermal matrix in the reconstruction of defects with exposed vital structures.

Methods

The retrospective case series was conducted in accordance with institutional guidelines conforming to the Declaration of Helsinki and informed written consent was obtained from patients. All patient information, including images were de-identified. This retrospective case series included five participants with six complex defects involving exposed structures (Table 1). The reconstructive procedures were conducted between 2018–2020 at two sites (New Orleans, Louisiana and Tawas City, Michigan). Where required, defects underwent aggressive sharp debridement to remove non-viable tissues, or full thickness excision. The OFM grafts (Myriad Soft Tissue Matrix, Aroa Biosurgery, Auckland, New Zealand) are engineered as multilayered devices comprising either 3-layer ('thin') or 5-layer ('thick') OFM bioscaffold. Devices are shelf stable at room temperature and were terminally sterilised. Graft thickness was selected by the surgeon based on the depth of the defect, then the grafts trimmed to fit the defect, rehydrated using sterile saline and placed in the defect, ensuring direct contact with the underlying tissues. Grafts were secured via suture or staple fixation and covered with a non-adherent contact layer. The OFM graft was applied only during the initial surgical procedure. Defects were regularly assessed for progress of graft incorporation and granulation tissue formation. When sufficiently granulated, STSGs were applied, apart from a single case of secondary closure (Case 2), and where the OFM graft was implanted (Case 6, Table 1). Regular assessment of STSG viability and defect epithelialisation was performed until complete healing, and the cosmetic and functional reconstructive outcomes evaluated.

Results

During preparation, both 'thick' (~1.5mm) and 'thin' (~1mm) OFM grafts were easily trimmed to fit the defect area and on hydration had excellent handling properties and mechanical strength. The OFM grafts notably

Table 1. Study participants

Case: Participant (sex, age)	Comorbidities	Defect type	Defect exposed structures	Previous management	Surgical management	Results
1 (F, 25)	Uncontrolled diabetes	Traumatic compression injury resulting in tissue ischaemia	Radial and ulnar arteries	Fasciectomies and debridements	OFM graft, NPWT, STSG	Complete granulation at 6 weeks; 100% skin graft take at 1 week; 100% epithelialisation at 9 weeks
2 (F, 25)	Uncontrolled diabetes	Secondary defect following z-plasty	Tendon	NA	Z-plasty scar revision, OFM graft, STSG	100% epithelialised after 4 weeks; elbow flexion improved from ~110° to 180°
3 (F, 98)	None, otherwise healthy	Full thickness tumour excision, scalp	Periosteum	None	OFM graft	Complete granulation in 2 weeks; closure by secondary intention after 8 weeks with good cosmetic outcomes
4 (M, 85)	Osteomyelitis	Non-healing surgical defect, scalp	Calvarium	Amniotic membrane graft (Epifix, MiMedx)	Full thickness excision, OFM graft, STSG	Complete granulation in 2 weeks; 100% epithelialised after 7 weeks
5 (F, 3)	Malnourished, pterygium syndrome	Surgical dehiscence; full-thickness hard-to-heal wound foot dorsum and calcaneus	Bone and tendon	Dermal substitute graft (Integra, Integra LifeSciences Corp)	OFM graft, STSG	Complete granulation in 1 week; 100% epithelialised in 2 weeks; long-term (3 months) improvements in function with 80% original ankle flexion restored
6 (M, 70)	Multiple comorbidities; complex ventral hernia after urologic cancer resection	Surgical dehiscence; non-healing abdominal sinus tract, adjacent to granulated bowel	Bowel	Wound debridement and NPWT	OFM graft implanted into tracking sinus, then STSG	Sinus tract closed at 3 weeks; STSG graft placed at 6 weeks; 100% epithelialised in 11 weeks

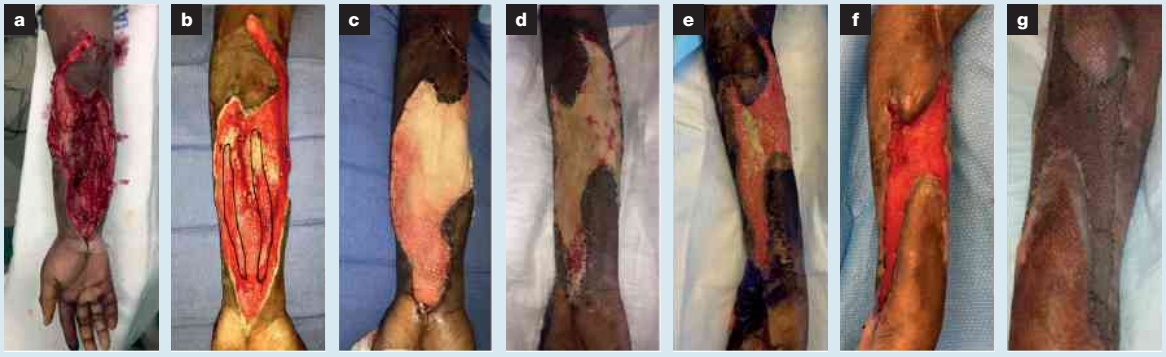
F—female; M—male; NA—not applicable; NPWT—negative pressure wound therapy; OFM—ovine forestomaach matrix; STSG—split-thickness skin graft

absorbed blood and blood components following placement. The availability of two graft thicknesses was useful when addressing the various depths seen in the defects managed, and avoided the need to layer multiple devices in the same defect. Fixation of the OFM graft via sutures or staples was straightforward, durably securing the graft to maintain contact with the underlying tissues and providing immediate coverage of exposed structures. Across all cases, initial signs of granulation tissue within the OFM graft appeared one to two weeks post application. Granulation tissue typically originated at the basal portion of the graft as small projections at the graft interstices that later merged into islands of granulation tissue. Defects were sufficiently granulated to receive an STSG within one to six weeks post application. As expected, larger defects required more time to completely granulate. Granulation tissue resulting from the OFM graft was well vascularised and a suitable substrate for an STSG. Where an STSG was used, 100% take of the STSG within one week was achieved and all defects were 100% re-epithelialised in two to three weeks. All defects healed with no complications, and no signs of infection were observed. All defects healed with good functional and cosmetic outcomes and patients reported high levels of satisfaction.

Case 1

A 25-year-old female patient with diabetes had been found down on her left arm for approximately 48 hours with diabetic ketoacidosis. Multiple fasciotomies and surgical debridements were required for the areas of necrotic tissue (Fig 1a). Soft tissue debridement was performed over one week, leaving radial and ulnar arteries visibly pulsatile and essentially exposed (Fig 1b) with debridement causing one artery to require arterial stitch repair. Soft tissue coverage was required to prevent arterial blowout. However, a large free flap procedure was not appropriate, given the patient's uncontrolled diabetes (HbA1c 14%), the risk of sacrificing another region to undertake a free flap and uncertainty of the future functional status of the arm. The patient refused below-elbow amputation recommended by the surgical team. Partial complex closure at the antecubital fossa and wrist was performed. Given the limited surgical options, the OFM graft was employed to provide immediate coverage and build granulation tissue in the defect. Due to the large defect size, two OFM grafts ('thick' 10×20cm and 'thick' 10×10cm) were quilted together with 4-0 chromic catgut suture, trimmed to fit the defect, hydrated in saline and placed in the defect with staple fixation (Fig 1c). A non-adherent dressing (Adaptic, Acelity Inc, San Antonio, Texas) was placed over the OFM graft, followed by a high-density negative pressure wound therapy (NPWT) foam dressing (V.A.C. WHITEFOAM, KCI Inc, San Antonio, Texas) and finally a low-density NPWT foam dressing (V.A.C. GRANUFOAM, KCI Inc). Continuous NPWT was performed at low pressure (75mmHg) due to the exposed arteries, with dressing changes twice per week. After four days, granulation tissue was visible in OFM graft interstices and in two weeks islands of granulation tissue were prominent throughout the graft and the distal graft portion was predominately robust granulation tissue (Fig 1d). Residual graft was debrided from the distal area and silver nitrate applied to mitigate hypergranulation. At this stage NPWT was ceased due to neuropathic pain at the periwound area, attributed to the extent of ischaemic neurologic injury. Hydrogel was applied to maintain a moist environment and the non-adherent dressing changed to an antimicrobial variant (Xeroform, Covidien, Dublin, Ireland). At three weeks granulation trajectory was well established, with the majority of the OFM graft resorbed into developing granulation tissue. After four weeks, only the mid volar forearm had residual OFM graft remaining and healthy granulation tissue was established throughout the rest of the defect (Fig 1e). Curette debridement was performed and dressing regimen maintained, resulting in complete granulation at six weeks (Fig 1f). An STSG

Fig 1. Traumatic wound of left arm with exposed vasculature (Case 1). Day 0, initial defect (**a**); Week 1, during debridement with exposed arteries outlined (**b**); Week 1, ovine forestomach matrix (OFM) graft placed (**c**); Week 2, formation of granulation islands in OFM graft (**d**); Week 4, defect near complete granulation with only small region of residual OFM graft remaining (**e**); Week 6, complete OFM graft incorporation and defect fully granulated (**f**); Week 7, 100% split-thickness skin graft take one week after placement (**g**)



(108cm^2, 0.3mm thick) was harvested and placed on the granulated defect, dressed with a silver contact layer (SilverIon) and NPWT applied for one week, resulting in 100% graft take (Fig 1g). Physiotherapy was initiated two weeks post STSG (eight weeks post initial intervention) and three weeks post STSG (nine weeks post initial intervention) and 100% defect epithelialisation was achieved, with functional improvements in wrist flexion and finger movement. Considering the initial circumstances of the injury and high risk of amputation, the patient was overwhelmingly pleased with the functional and cosmetic outcomes achieved.

Case 2

The same 25-year-old female patient (Case 1) underwent planned scar revision to release flexion crease, with revision surgery taking place one week after complete epithelialisation of the initial defect described above (four weeks post STSG and ten weeks post initial intervention). Scar contracture below the elbow (Fig 2a) was released via excision and the crucial flexion crease region reconstructed with local tissue by Z-plasty. Due to the significant prior ischaemic injury, release of deep scar tissue distal to the elbow created a secondary defect (Fig 2b). An OFM graft ('thin' 10×10cm) was trimmed to fit and placed in the defect (Fig 2c) secured via suture and conventional bolster and split. Two weeks post Z-plasty, scar release resulted in flexion improvement (from ~110° to ~180°) and the secondary defect was fully granulated (Fig 2d). An STSG was placed with complete graft take in one week and 100% epithelialisation two weeks post STSG placement (four weeks post scar revision) (Fig 2e).

Case 3

A 98-year-old female patient presented with Bowenoid squamous cell carcinoma in situ located on the forehead (Fig 3a). Initial tumour size was estimated to be ~1.5×1.5cm. Full-thickness excision of the tumour and margins down to periosteum was performed under general anaesthetic, creating a ~2.1×2.7cm defect (Fig 3b). Due to the defect location, depth and the patient's preference to avoid a donor-site wound, immediate coverage with an STSG was discounted. Instead, an OFM graft was used to provide coverage of the periosteum, and regenerate granulation tissue in the defect void, with closure via secondary healing. An OFM graft ('thick' 5×5cm) was trimmed, rehydrated in saline and placed to ensure good apposition to the underlying periosteum (Fig 3c). The graft was secured with 4-0 chromic suture and a bolster dressing of mineral oil, cotton balls and petrolatum dressing (Xeroform) with tie over silk suture compression. Two weeks post surgery, the OFM graft was integrating, and becoming vascularised with some residual graft visible (Fig 3d). After six weeks, 80% of the defect had re-epithelialised (Fig 3e), and the defect fully healed at eight weeks (Fig 3f). The patient was very satisfied with the cosmetic outcome achieved without the need for an STSG.

Case 4

An 85-year-old male patient with numerous prior scalp skin cancers presented with a two-year-old non-healing wound on the scalp vertex resulting from prior Mohs excision of squamous cell carcinoma (Fig 4a). Tissue surrounding the defect was abnormal and the defect had a history of methicillin-resistant *Staphylococcus aureus* (MRSA) and *Staphylococcus lugdunensis* infection, with outer table calvarial osteomyelitis confirmed by MRI. Previous treatment of the defect with amniotic membrane allograft (Epifix, MiMedx, Marietta, Georgia) was unsuccessful, likely due to the underlying osteomyelitis and the chronicity of the dermal tissues. Full-thickness excision of the defect and surrounding

Fig 2. Z-plasty scar revision of left arm (Case 2). Day 0, initial presentation with incision plan marked (**a**); Day 0, post-z-plasty showing secondary defect in profile (top) and top-down (bottom) perspectives (**b**); Day 0, placement of ovine forestomach matrix graft in secondary defect depicted in profile (top) and top-down (bottom) perspectives (**c**); Week 2, secondary defect fully granulated (**d**); Week 4, secondary defect (circled) fully epithelialised two-weeks after split-thickness skin graft placement (**e**)

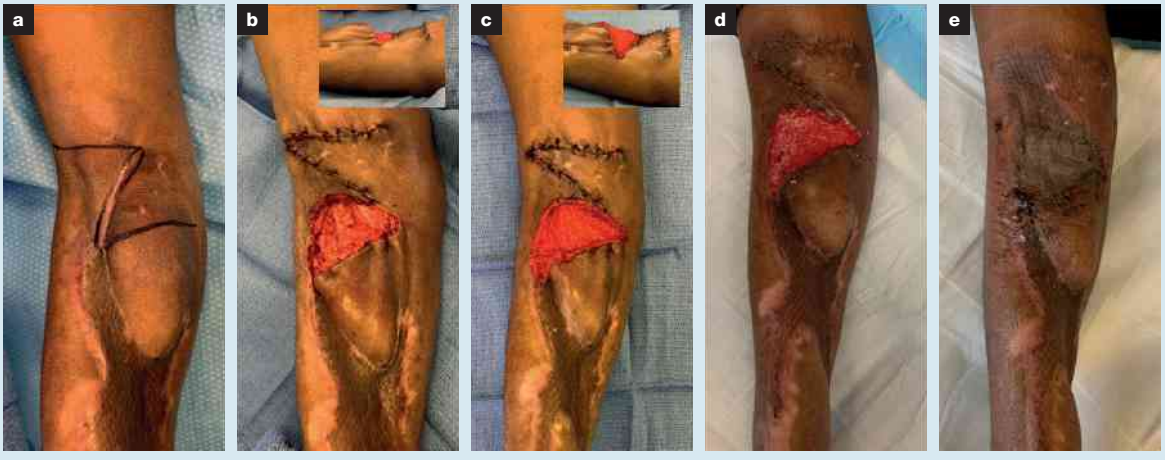
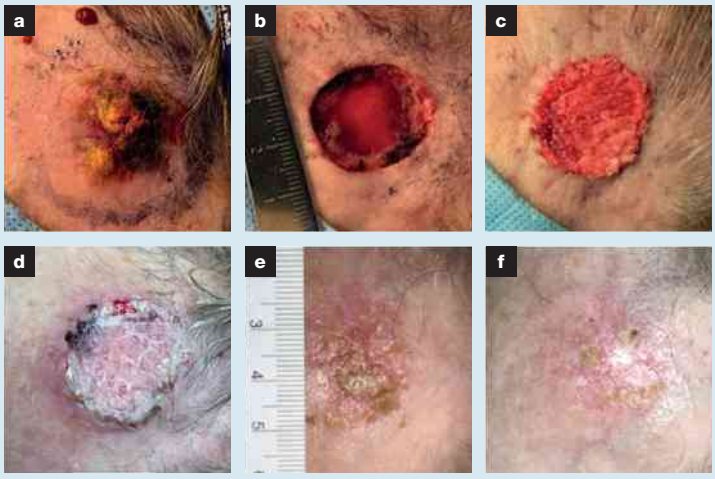


Fig 3. Scalp tumour excision defect (Case 3). Day 0, initial carcinoma (**a**); Day 0, surgical defect created follow tumour excision (**b**); Day 0, ovine forestomach matrix (OFM) graft placement (**c**); Week 2, OFM graft integrating with some residual graft visible (**d**); Week 6, 80% re-epithelialisation of defect via secondary intention (**e**); Week 8, complete secondary closure of defect (**f**)



abnormal scalp region was performed, irregular central calvarial bone consistent with osteomyelitis found and the outer table was debrided with a pineapple burr to punctate bleeding. The resulting defect measured 7.0×6.5cm with the calvarium not intact (Fig 4b). An OFM graft ('thick' 10×10cm) was cut to fit, rehydrated in saline and placed directly contacting the exposed bone, secured to defect edges with 4-0 chromic suture (Fig 4c) and compression via silk suture tie over bolster dressing (Fig 4d). After two weeks, granulation tissue was observed within the graft material (Fig 4e) and the outer (top) graft layer removed via gentle traction revealing complete incorporation of the inner graft layers into newly formed granulation tissue (Fig 4f) and no signs of infection within the defect area. At four weeks post initial surgery, an STSG (0.3mm thick) was applied (Fig 4g) and 100% graft take achieved one week after placement. Three weeks after STSG placement (seven weeks post initial surgery) the defect had completely epithelialised (Fig 4h), with the healed area demonstrating good contour, colouration and functional elasticity.

Case 5

A 3-year-old female patient with pterygium syndrome underwent an orthopaedic procedure of the left foot resulting in wound dehiscence and infection. The patient was admitted malnourished and presented a full-thickness tissue deficit with exposed bone and tendon (Fig 5a). Previous treatment using a reconstituted collagen/glycosaminoglycan dermal matrix (Integra) was unsuccessful. Due to the defect location, flap reconstruction was ruled out by the surgical team. The defect was debrided and an OFM graft ('thick' 10×20cm) was placed, conforming to the defect bed and covering the exposed bone and tendon. The graft was secured via staples at the margins (Fig 5b) and covered with a non-adherent layer (SilverIon, Argentum Medical, Geneva, Illinois), silver alginate dressing for moisture retention and finally cast padding wrap and split. At one-week follow-up, graft incorporation was apparent with granulation tissue visible through the graft material (Fig 5c). The extent of granulation tissue was sufficient for STSG placement (0.3mm thick). Complete STSG take to the neodermis was observed one week post STSG placement (two weeks post initial OFM graft placement) (Fig 5d). At long-term follow-up, three months post STSG placement, movement of the joint had nearly returned to pre-operation status, with only ~20% loss of ankle flexion, and regenerated dermis demonstrated good cosmesis and functional elasticity (Fig 5e).

Discussion

Exposed vital structures in soft tissue defects require prompt and durable stabilisation during reconstruction to protect and maintain vitality up to definitive closure. Defects with exposed vital structures often lack the vascular supply required to reliably support direct STSG placement. Thus, gold standard treatment is coverage by a well vascularised flap that can sustain and protect the exposed structures, while providing immediate coverage. However, the use of flap-based reconstruction may be limited by donor site morbidity concerns, the absence of sufficient donor tissue or a lack of subspecialty training.[2]

Scientific research has continued to advance our understanding of tissue ECM and in parallel the development of regenerative bioscaffolds, like dermal matrices, that aim to mimic tissue ECM to scaffold soft tissue regeneration.[15] Correspondingly, the traditional reconstructive ladder has evolved to include dermal matrices as an additional option for surgically managing complex soft tissue defects.[16,17] The objectives of treating defects with denuded vital structures with dermal matrices is to provide an initial protective coverage to exposed structures, then temporise the defect via scaffolding granulation tissue formation. Once granulation tissue has been regenerated, closure may be achieved via skin grafting or closure via secondary intention. Reflecting their uptake in clinical practice, the use of dermal matrices in reconstruction involving exposed structures has been reported widely.[1,18–20]

A variety of dermal matrices are now commercially available, including synthetic bioscaffolds and a range of decellularised ECM grafts derived from human and animal tissues.[15] Synthetic bioscaffolds use processes that synthesise bioscaffolds from component raw materials (e.g., synthetic polymers, reconstituted collagen, chondroitin sulphate or elastin) to create biomaterials of defined pore and fibre size. Decellularised ECM bioscaffolds represent a newer evolution in bioscaffold design, and rather than being synthetic, these products are produced using processes to isolate an intact tissue ECM from mammalian tissue sources. The tissue ECM

undergoes decellularisation to remove any cellular components from the raw tissue starting material, and retains the structure and composition of tissue ECM.[15]

In the treatment of defects with exposed vital structures, the most well characterised dermal matrix product is a synthetic product comprising reconstituted collagen crosslinked to chondroitin sulphate (Integra).[1,16,17,19] In comparison, the OFM graft consists of decellularised ECM and therefore has a significantly more diverse composition. For example, while also containing collagen and glycosaminoglycans,[7] a proteomic characterisation of the OFM biomaterial identified over 150 unique matrix proteins that naturally exist in soft tissue ECM and are known to play a role in soft tissue repair.[6] This includes a range of structural proteins, with 19 different collagens, adhesion proteins (e.g., fibronectin, tenascin) and signalling molecules such as growth factors (e.g., FGF2, PDGF, EGF and IGF), and inhibitory proteins (e.g., TIMP4).[6] Additionally, structural studies demonstrate that OFM retains a native matrix architecture similar to the ECM of healthy human skin.[9] This structural and compositional mimicry of healthy tissue ECM facilitates a range of biological properties, for example OFM to inhibit a range of tissue proteases,[21] and stimulate cell migration, infiltration, proliferation and differentiation,[7,8,22] and the recruitment of mesenchymal stromal cells.[10] In comparison to a synthetic dermal matrix, such as reconstituted collagen/glycosaminoglycan, the OFM graft is expected to impart greater biological functionality, attributed to a preserved ECM structure and composition.

In the present cases, we observed the OFM graft closely conformed to the defect bed and provided a durable protective layer to the defect and exposed vital structures. We noted that even when previously rehydrated in saline the OFM graft rapidly absorbed blood and blood components in situ, which may provide additional regenerative properties to the graft. In all cases we noted robust granulation tissue formation as the OFM graft integrated into the regenerating tissue. Our clinical observations are in agreement with previous reports demonstrating that the OFM biomaterial stimulated angiogenesis and vasculogenesis in vitro, ex vivo and in vivo.[8] Additionally, the physical design of the graft, including layers of OFM and regular interstitial perforations, appeared to guide cell infiltration and granulation tissue formation, with early granulation tissue observed in the graft interstices that later merged to distinct islands of granulation tissue. The availability of two thickness options (3-layer and 5-layer) allowed a graft to be selected to best suit the depth of the particular defect. However, the choice of graft thickness must take into consideration the entire reconstructive timeline, as graft thickness, as well as patient factors, will dictate the time to complete graft incorporation. Another procedural benefit of the OFM graft is the ability to implant the device to reinforce and rebuild subcutaneous soft tissues. For example, in Case 6 (Table 1), a non-healing abdominal sinus tract was packed with the OFM graft to close the tunnelled wound, thus preventing an enterocutaneous fistula forming in this patient. While the authors have considerable experience with reconstituted collagen/glycosaminoglycan grafts, the relatively high reported

Fig 4. Tumour excision with exposed bone and damaged calvarium (Case 4). Day 0, initial presentation of chronic defect and surrounding abnormal tissue (**a**); Day 0, full-thickness surgical defect after excision, calvaria not intact (**b**); Day 0, ovine forestomach matrix (OFM) graft applied to defect (**c**); Day 0, compression of OFM graft via bolster dressing (**d**); Week 2, granulation tissue formation within OFM graft with residual OFM graft present (**e**); Week 2, residual OFM graft removed, defect well granulated with no signs of infection (**f**); Week 4, split-thickness skin graft (STSG) applied to granulated defect (**g**); Week 7, completely epithelialised defect 3-weeks post STSG (**h**)

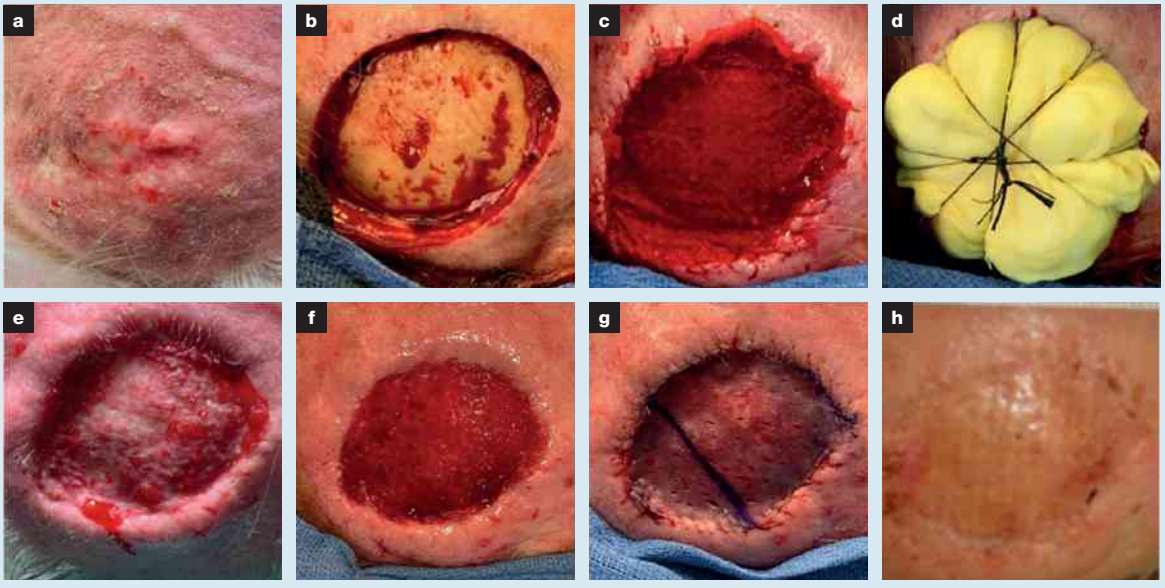
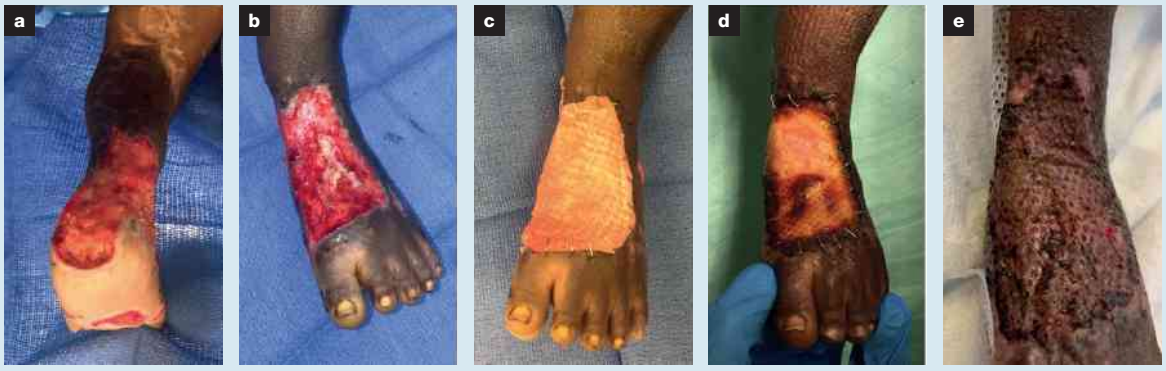


Fig 5. Paediatric wound dehiscence with exposed bone and tendon (Case 5). Proximal (**a**) and dorsal (**b**) aspect of full-thickness defects with exposed vital structures following surgical wound dehiscence and infection; Day 0, ovine forestomach matrix (OFM) graft placement (**c**); Week 1, granulation tissue visible within OFM graft and defect ready for skin grafting (**d**); Week 2, 100% STSG take one-week after split-thickness skin graft placement, dorsal perspective (**e**)



rates of infection[23–25] associated with this product raised concerns with using this graft in the presence of potential infection. No infections were observed in the use of the OFM graft, even in previously contaminated sites (Cases 4 and 5). While further studies are warranted to quantify infection rates using the OFM graft, it is interesting to speculate on the absence of infections seen in this pilot series. The biology and structure of the OFM bioscaffold have been shown to aid rapid vascularisation that may hinder microbial challenge through the delivery of immune components to the site. Additionally, it has been shown in previous studies that decellularised ECM bioscaffolds contain naturally occurring antimicrobial proteins that may also limit infection.[26]

Conclusion

When determining reconstructive strategy, the surgeon must consider specific defect and patient factors while also balancing procedural complexity, time and cost with the probability of best long-term aesthetic and functional outcomes for the patient. A number of strategies are available to the reconstructive surgeon and technological advances have provided new options on the reconstructive ladder for the treatment of soft tissue defects, such as the use of dermal matrices in the reconstruction of defects with denuded vital structures. Dermal matrices do not replace the need for established flap procedures, but these materials provide a range of additional options in the surgeon's repertoire to consider when determining the best reconstructive approach. The present work represents our initial clinical experience using an OFM graft and indicates the utility of this ECM-based dermal matrix in the reconstruction of challenging defects complicated by exposed vital structures. These cases support further controlled studies to assess the clinical performance, health economics and long-term outcomes of the OFM graft compared to other dermal matrices. **JWC**

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Reflective questions

- When managing extensive soft tissue loss with exposed bone or tendon, how often is immediate placement of a split thickness skin graft appropriate?
- A dermal substitute can be used to build granulation tissue over exposed bone but the formation of granulation tissue of can be rate limiting. Typically, how long does complete integration of a dermal substitute take?
- When using a dermal substitute as part of a staged procedure, how often does reconstruction become complicated by infection of the dermal substitute?